Assessing the Global Precipitation Measurement Level II and Level III with Multi-Radar/Multi-Sensor: current status and future directions

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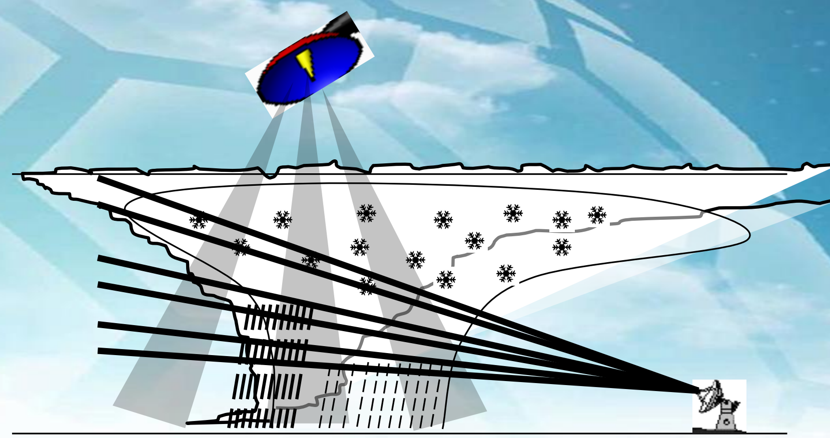


NASA 2017 Precipitation Measurement Missions Science Team Meeting – San Diego, October 18, 2017

Assessing GPM with MRMS:
current status and future directions

1. Context: MRMS & comparison framework

2. Active sensor: Dual-frequency Precipitation Radar

3. Passive sensor: GPM Microwave Imager

4. Multi-satellite: Integrated Multi-satellitE Retrievals

5. Conclusions & perspectives

Overview of the Multi-Radar Multi-Sensor System (MRMS)

Domain: 20-55° N, 130-60° W

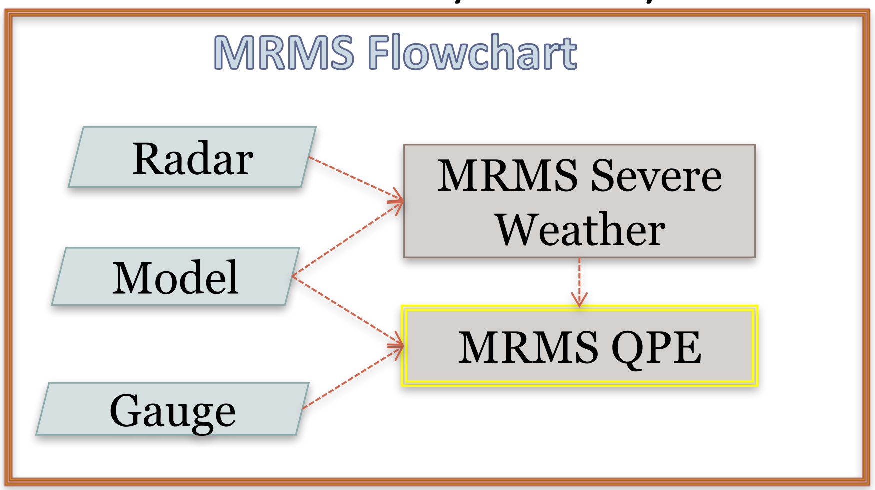
Resolution: 0.01° , 2 min update cycle

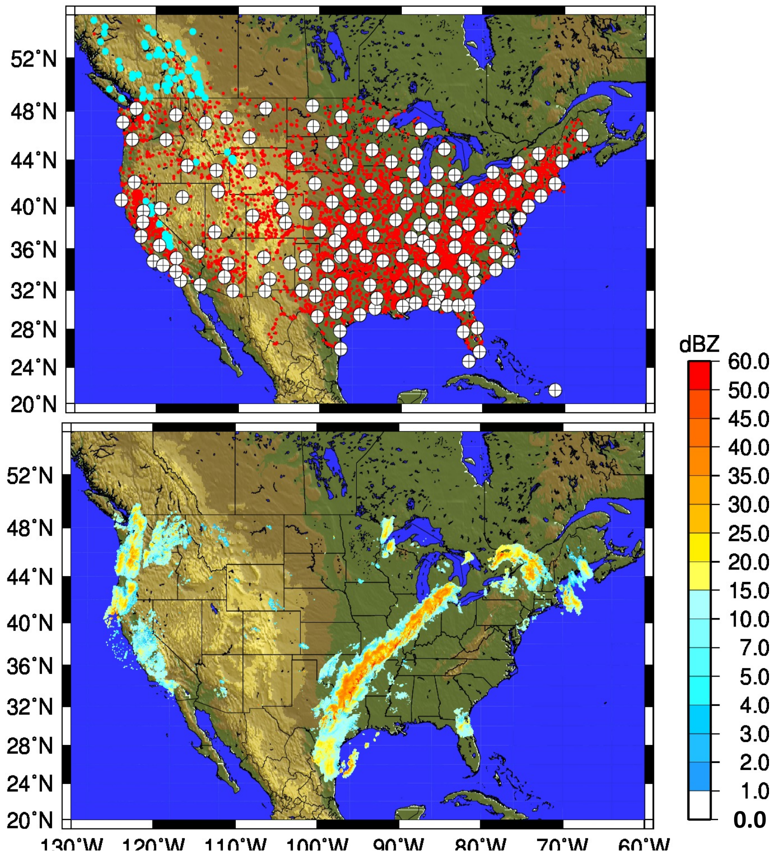
Data Sources:

~180 polarimetric radars every 4-5min

~9000 gauges every hour

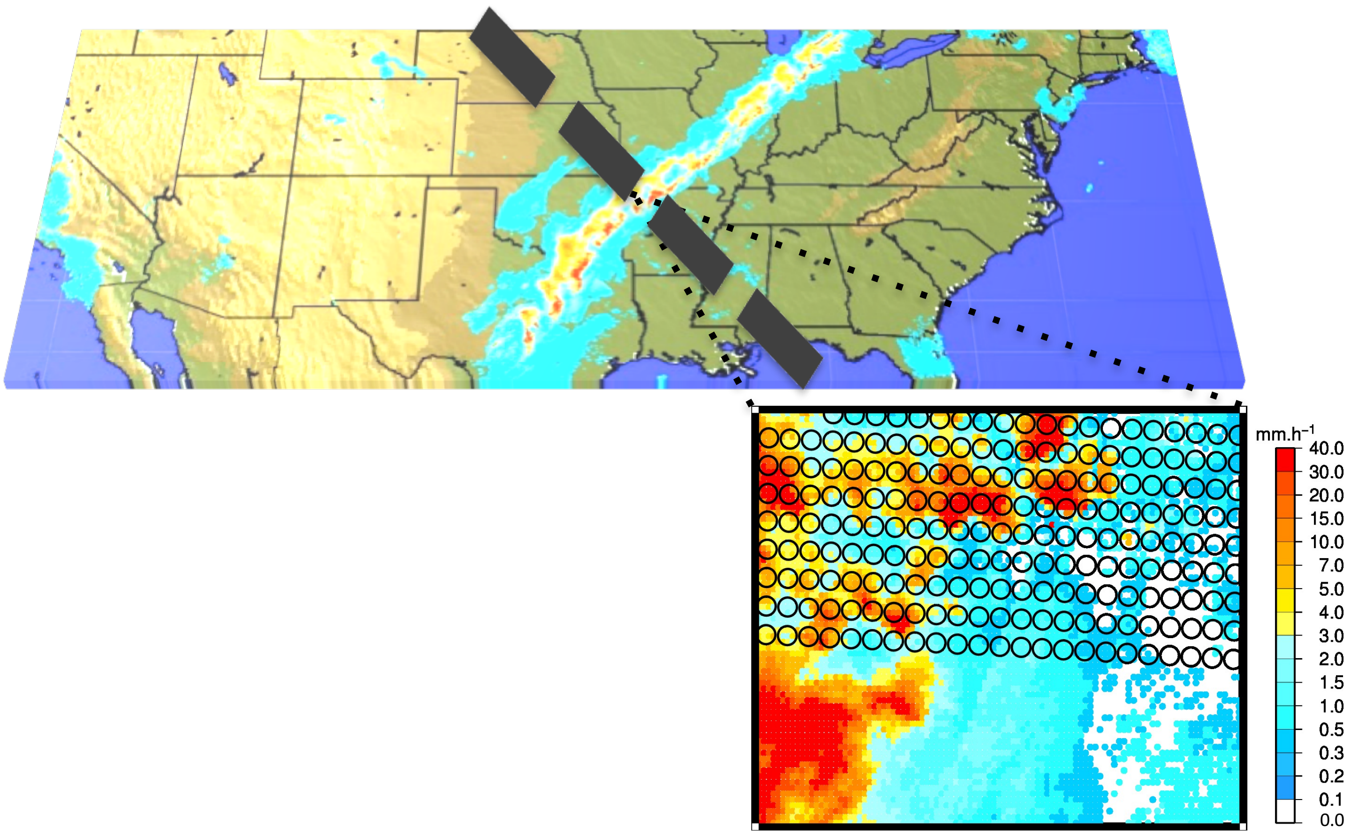
- RAP model hourly 3D analyses

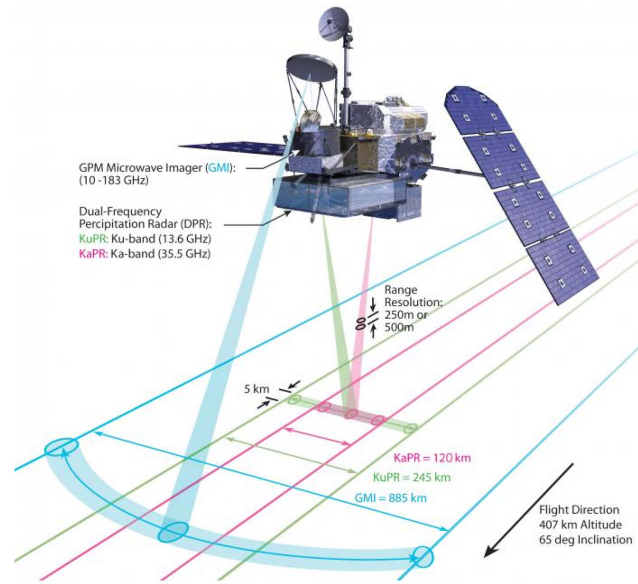




frontal system at 0800 UTC on 11 April 2011

GPM and MRMS

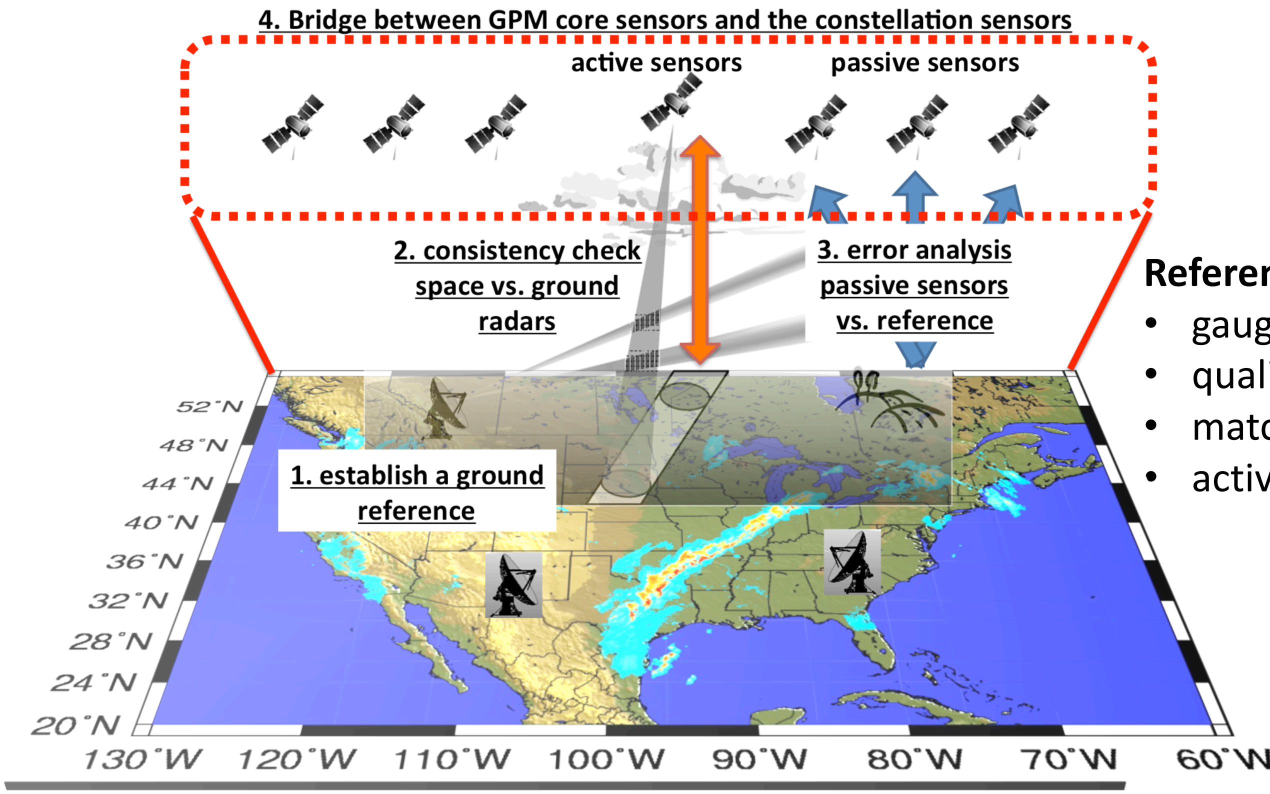




Precipitation features:

- intermittency
- type
- rate variability

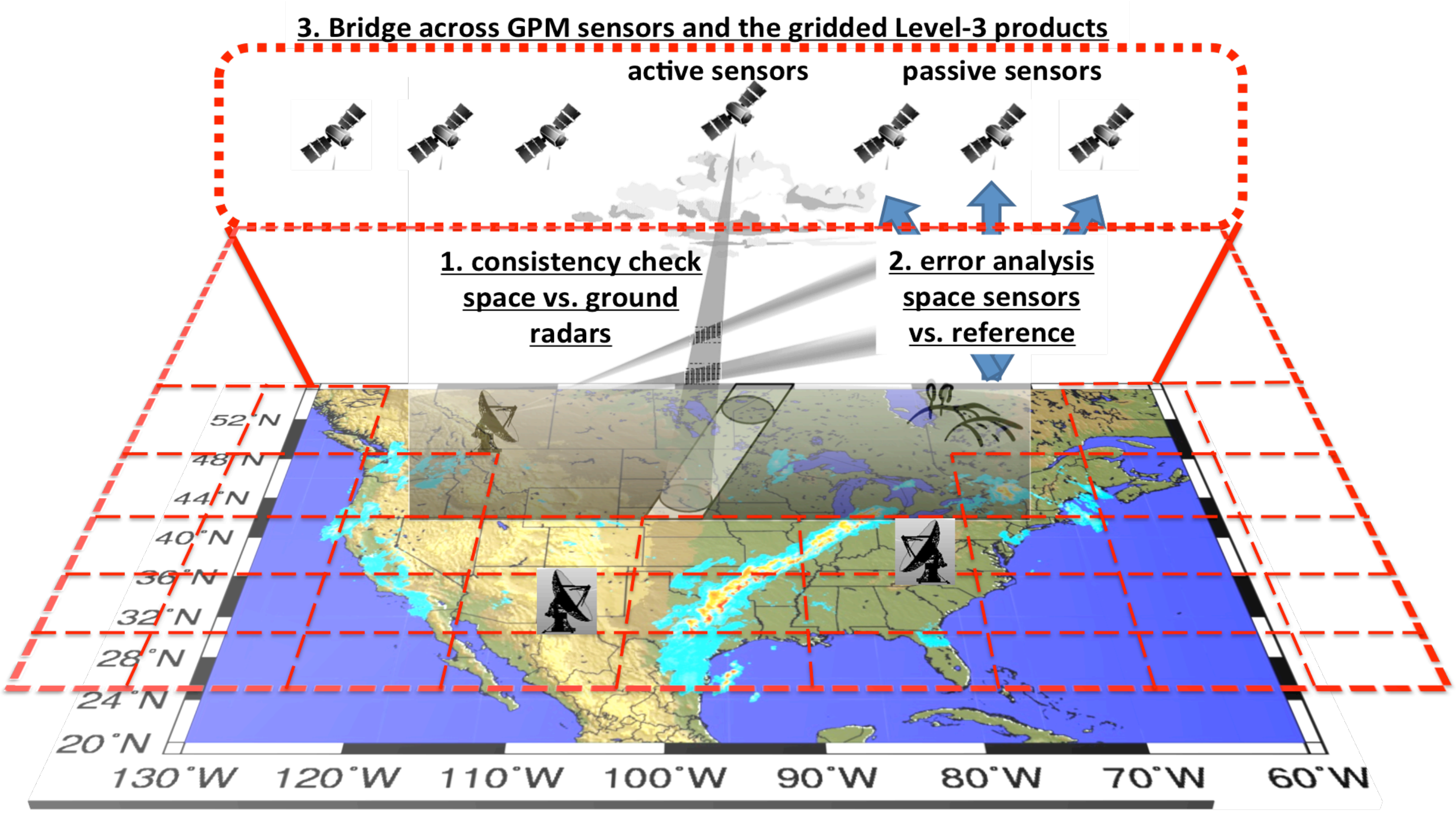
Comparing GPM with MRMS: bridging the Core and Constellation Sensors



Reference precipitation added value:

- gauge adjustment
- quality/quantity controls
- matching the resolution of each sensor/product
- active & passive Level 2, Level 3

Comparing GPM with MRMS: bridging Level-2 and Level-3 precipitation products



- impact on Level II & III retrieval algorithms

Assessing GPM with MRMS: current status and future directions

1. Context on MRMS and GPM

2. Dual-frequency Precipitation Radar

   - diagnostic: influence of parameters
   - prognostic: probabilistic QPE

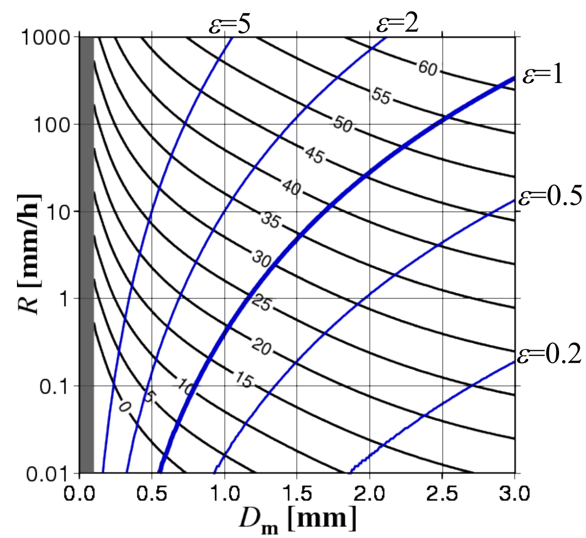
3. GPM Microwave Imager

4. IMERG

5. Conclusions & perspectives

Dual-frequency Precipitation Radar
Assumed relations between DSD parameters in V05

- **Rainfall – mass weighted mean diameter relation: R-Dm**
  - **stratiform:** $R_{DPR} = 0.401\ \varepsilon^{4.649}\ D_m^{6.131}$ **ε : adjustment parameter**
  - **convective:** $R_{DPR} = 1.370\ \varepsilon^{4.258}\ D_m^{5.420}$ **Dm: mean diameter**
- **Questions:**
  - **Do the constant values depend on precipitation regimes, types, ...?**
  - **What is the room for improvement?**
- **Methodology**
  - **stratiform:** $R_{ref} \Leftrightarrow 0.401\ \varepsilon^{4.649}\ D_m^{6.131}$
  - **convective:** $R_{ref} \Leftrightarrow 1.370\ \varepsilon^{4.258}\ D_m^{5.420}$



courtesy Seto-san

Dual-frequency Precipitation Radar
Conditional biases

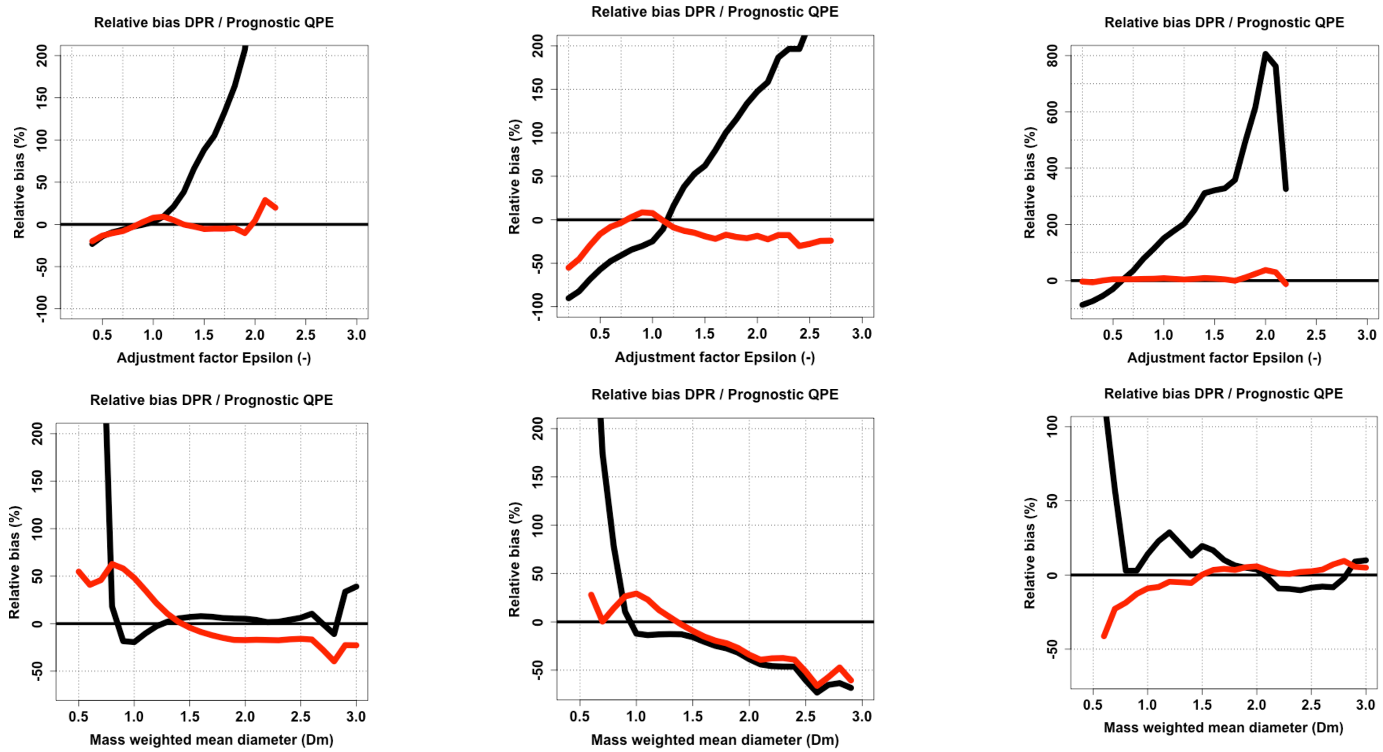
DPR QPE = f (ε, D_m, precipitation type, …)

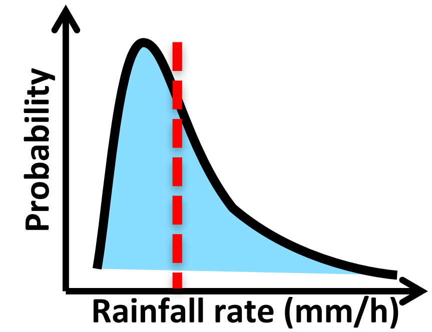
PDF(R_{ref}) = f (ε, D_m, precipitation type, …)

brightband | **stratiform** | **convective**

ε

D_m





DPR - MS

PQPE expectation

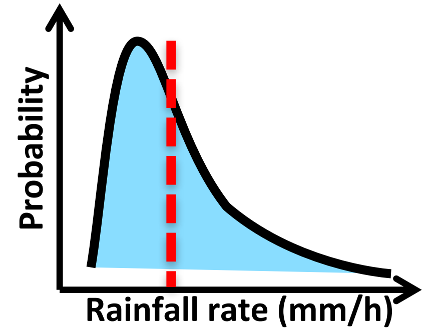
Dual-frequency Precipitation Radar Scores

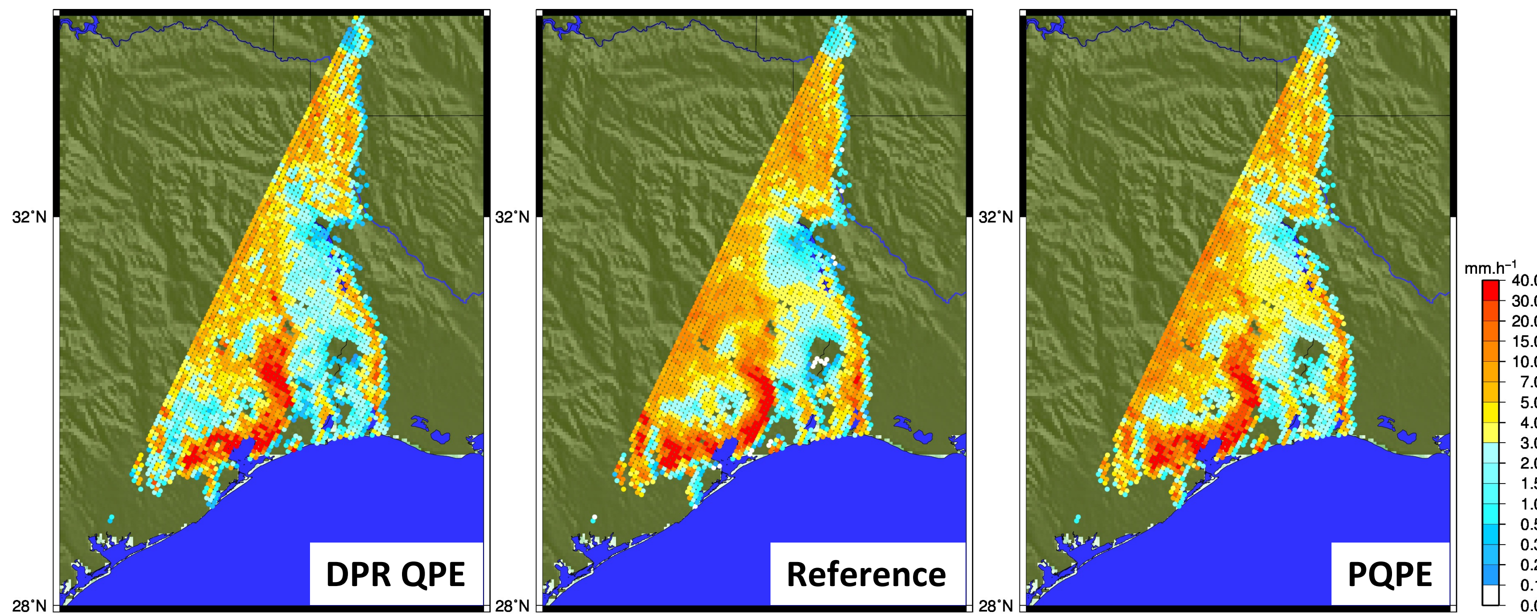
	brightband		stratiform		convective	
	ε	D_m	ε	D_m	ε	D_m
DPR	4.649	6.131	4.649	6.131	4.258	5.420
PQPE	2.321	3.941	1.833	3.165	1.647	3.365

	brightband		stratiform		convective	
	Bias	Correlation	Bias	Correlation	Bias	Correlation
DPR	+0.46	0.54	-21.0%	0.35	-8.9%	0.37
PQPE	-0.32%	0.61	-3.3%	0.43	+2.89%	0.52

Dual-frequency Precipitation Radar
Probabilistic QPE

DPR-NS PQPE = f (reflectivity,
precipitation type,
incidence angle)





Storm system at 12:30 UTC on 18 April 2016 near Houston

Dual-frequency Precipitation Radar
Probabilistic QPE

DPR PQPE = f (reflectivity,
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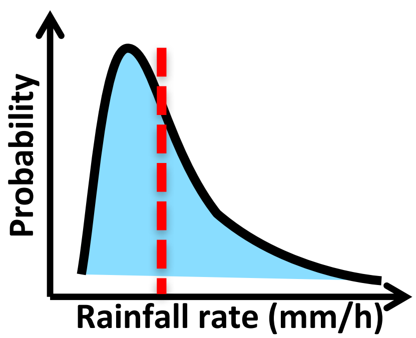

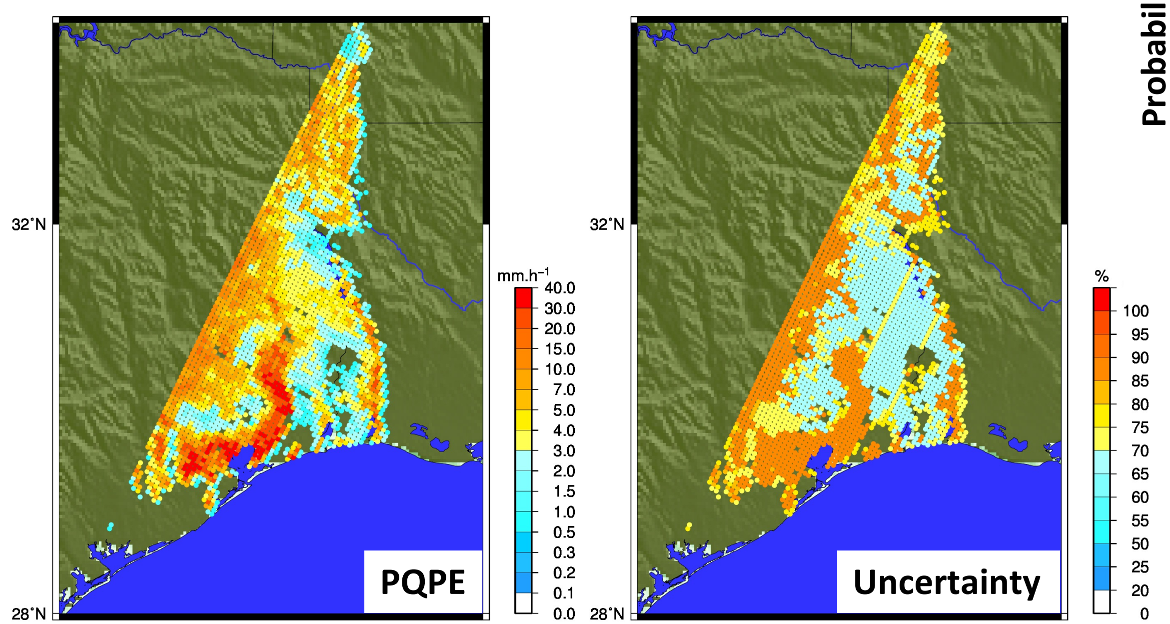

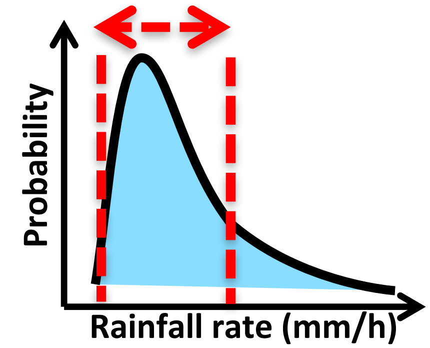

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Assessing GPM with MRMS: current status and future directions

1. Context on MRMS and GPM

2. Dual-frequency Precipitation Radar

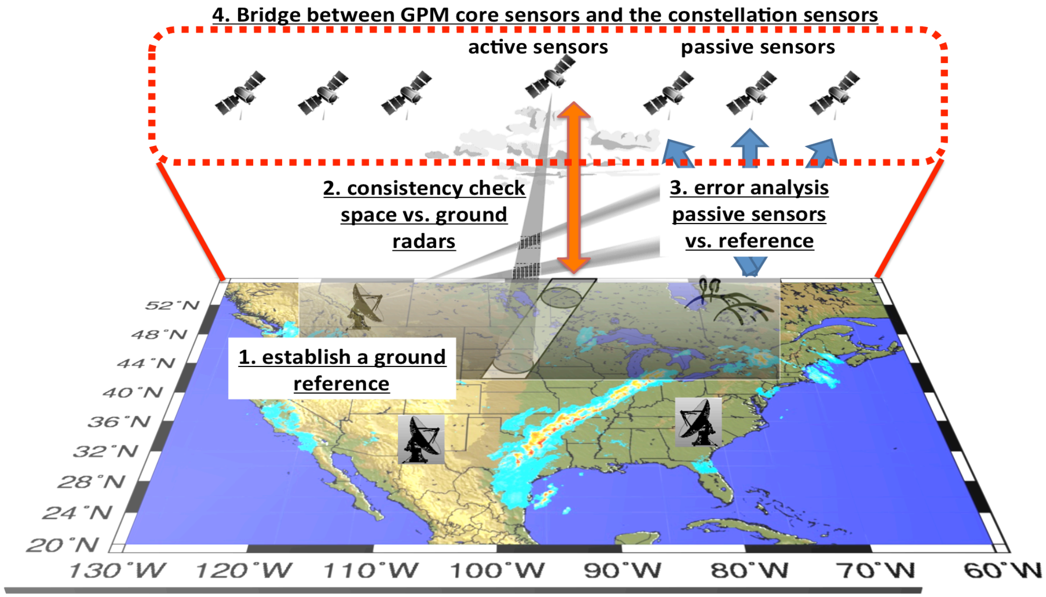
3. GPM Microwave Imager

    - influence of surface

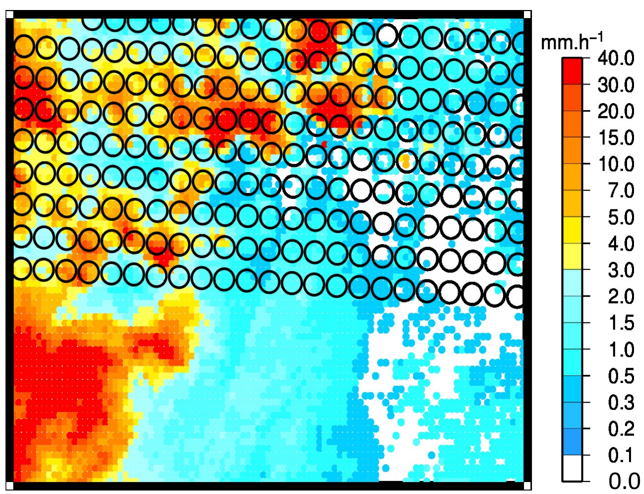
    - precipitation types in GRPOF next version

4. IMERG

5. Conclusions & perspectives



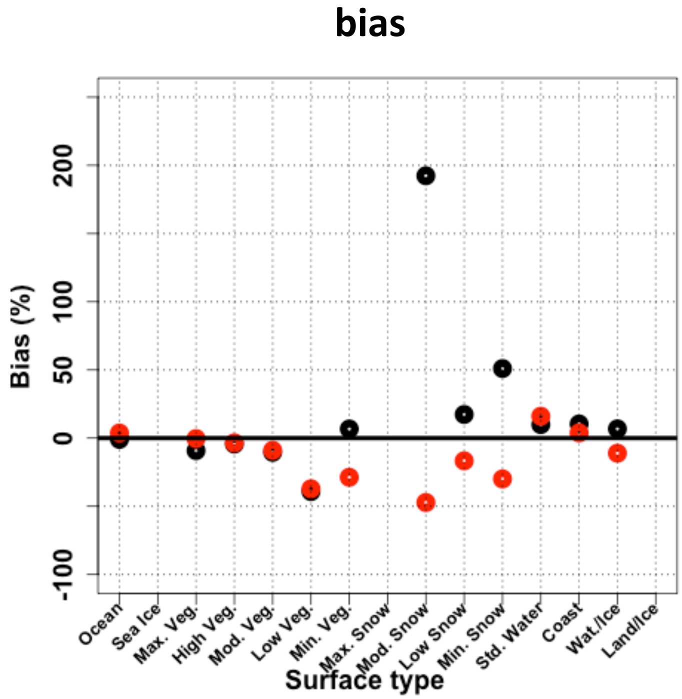
- period: 05/14 – 10/16
- ~6.5 millions matched pairs

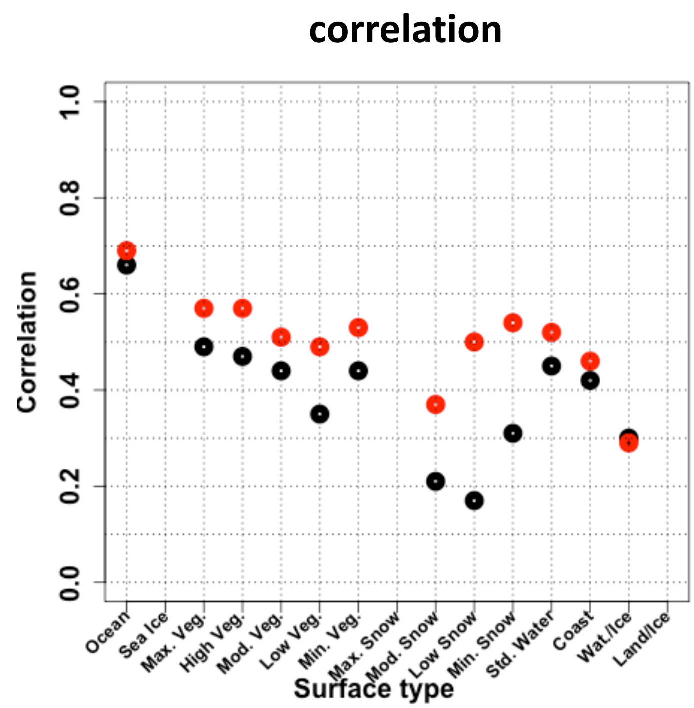


- detection
- rain / snow classification
- precipitation types
- quantification

GMI surface type – V04 vs V05: bias and correlation

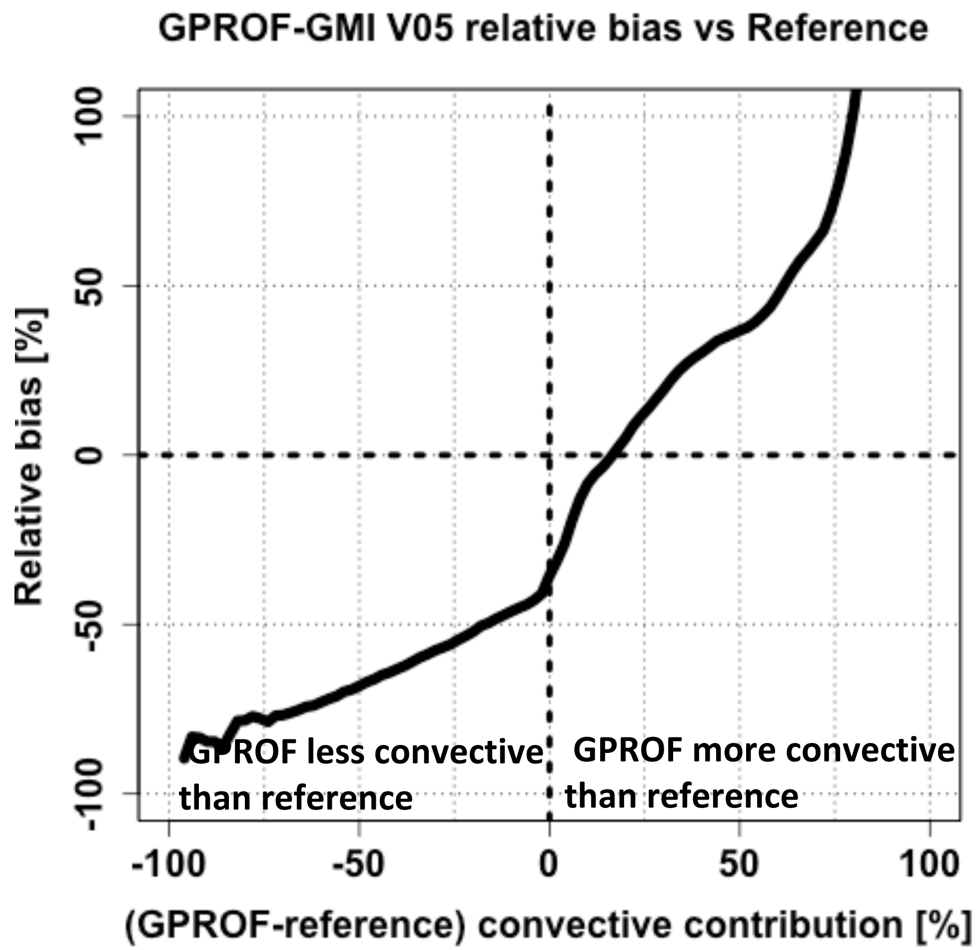
Conditions of comparison:
rain estimates (GPROF & reference)
reference beam filling > 50%
rates > 0.01 mm/h (GPROF & reference)





Toward the next GPROF version: convective contribution

- currently GPROF does not condition the retrieval by precipitation types (convective/stratiform)
- Can we see an improvement in precipitation rate estimates if GPROF correctly estimates the convective contribution?



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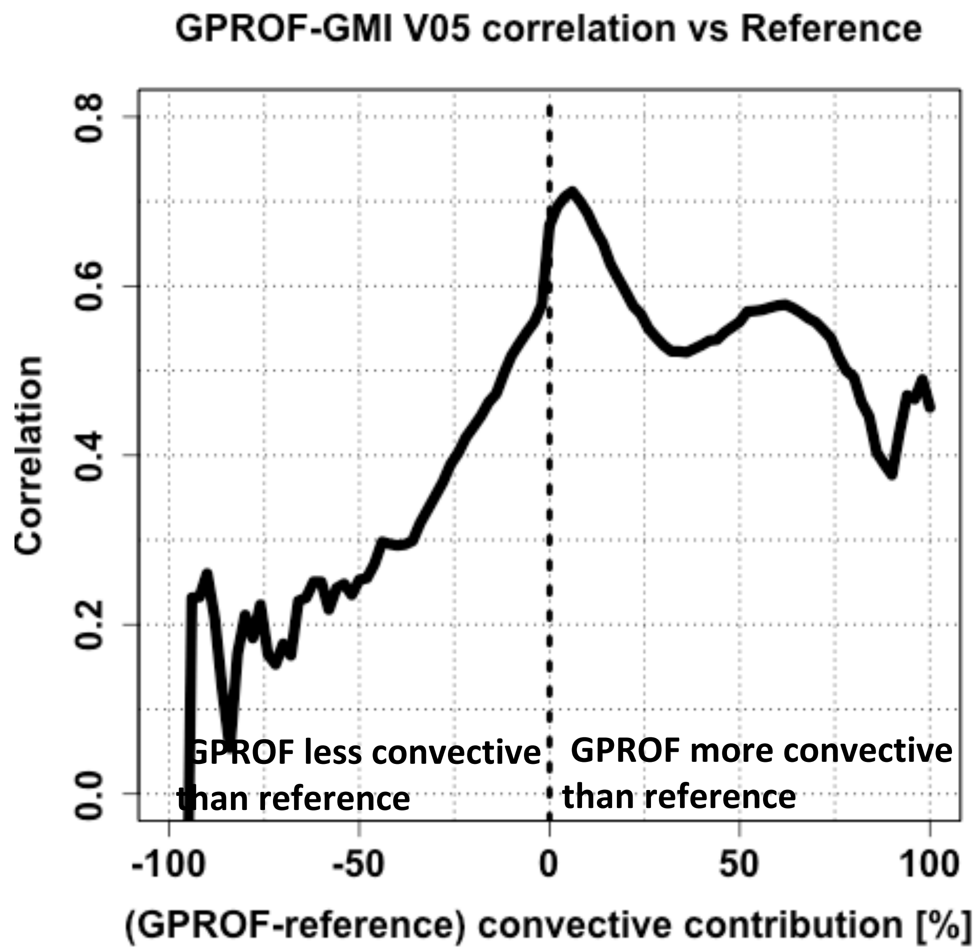


Assessing GPM with MRMS: current status and future directions

1. Context on MRMS and GPM

2. Dual-frequency Precipitation Radar

3. GPM Microwave Imager

4. **IMERG**

    - **precipitation types**
    - **probabilistic QPE with Infrared observations**

5. Conclusion & perspectives

From Level 2 to Level 3

- **Objective: mitigate propagation of Level 2 biases to Level 3 precipitation products**

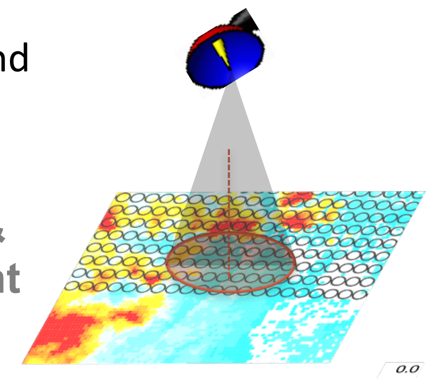
satellite Level 3 developers have specifically required the inclusion of error and uncertainty fields

Satellite L2
- **orbital**
- **instantaneous**

comparison

Reference L2
- **1km / 2min**

evaluation & improvement



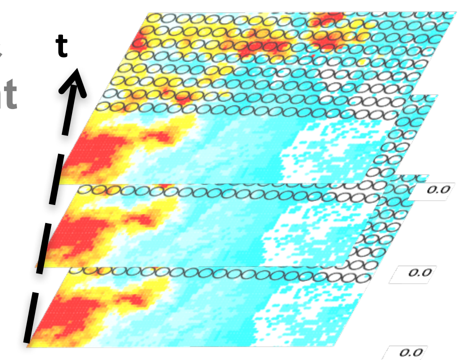
scale impact

Satellite L3
- **gridded**
- **30-min**

comparison

Reference L3
- **1km / 30min**

evaluation & improvement

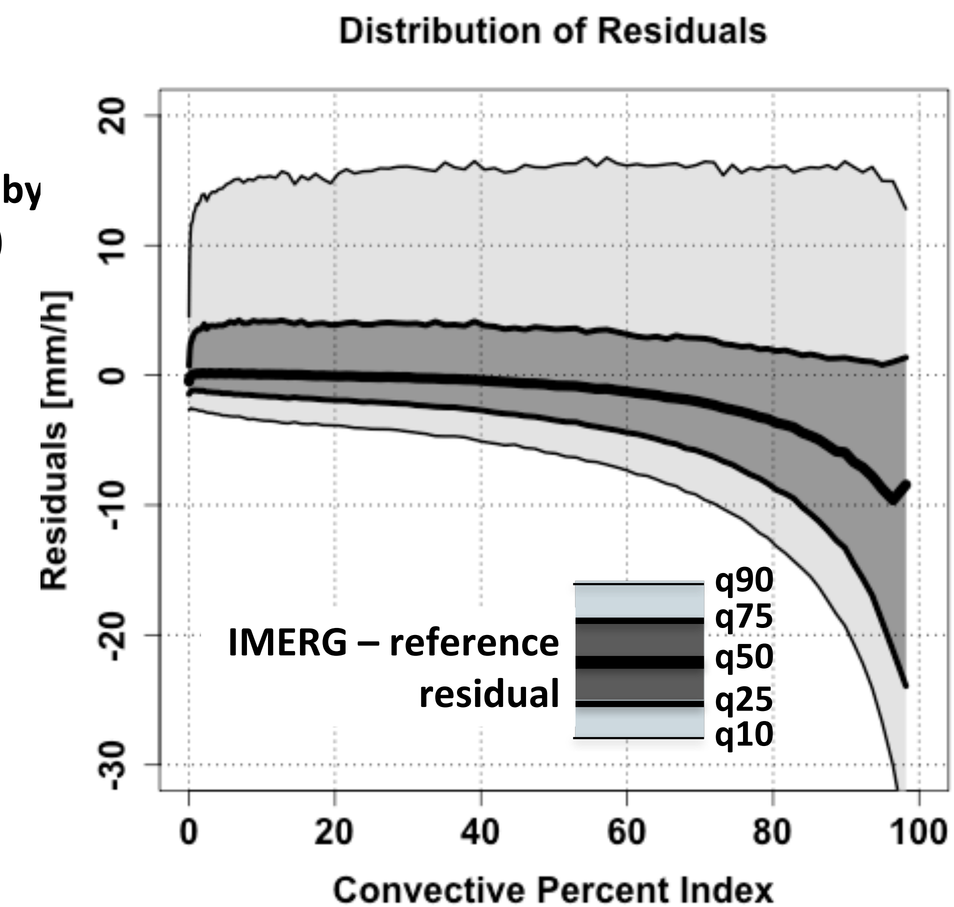


Precipitation features:
- intermittency
- type
- rate variability

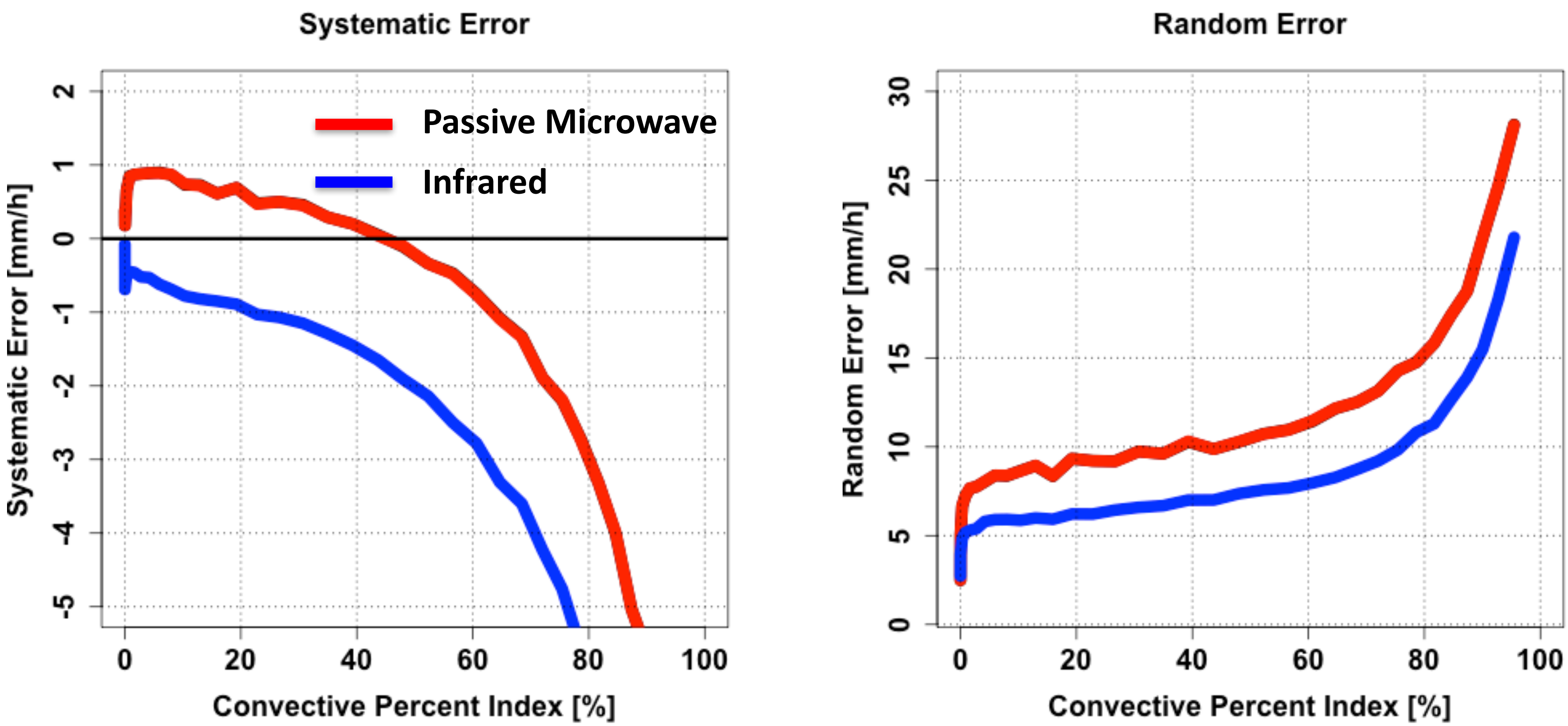
IMERG diagnostic analysis: convective index

- currently GPROF does not condition the retrieval by the precipitation typology (convective/stratiform)

➔ It probably propagates into IMERG

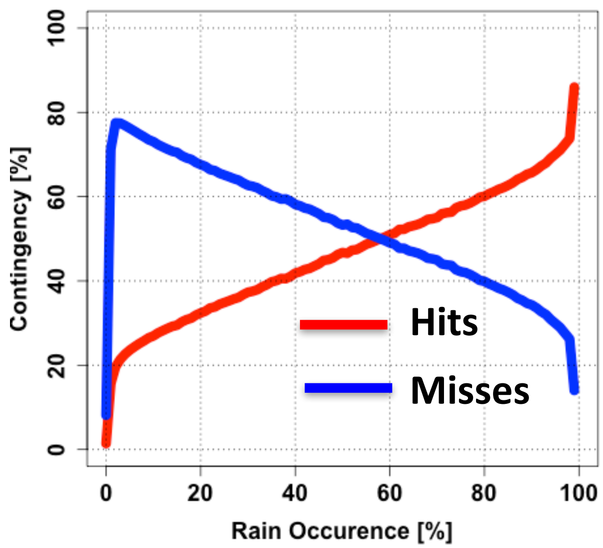


IMERG diagnostic analysis: convective index



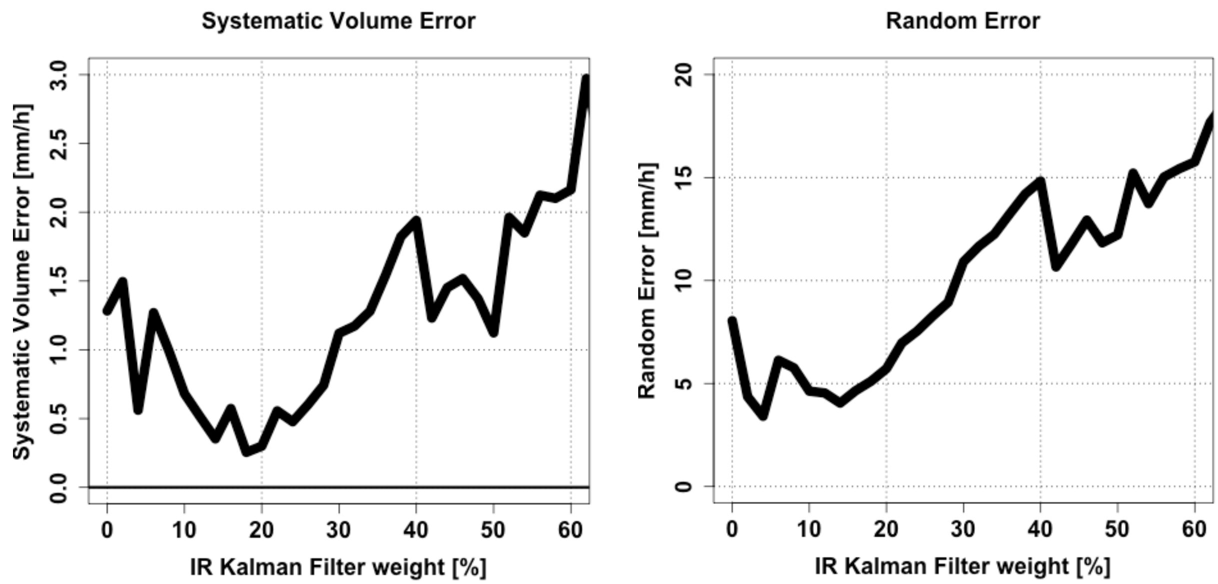
IMERG diagnostic analysis: other factors

IMERG detection



Strongly depends on intermittency

Combining PMW and IR



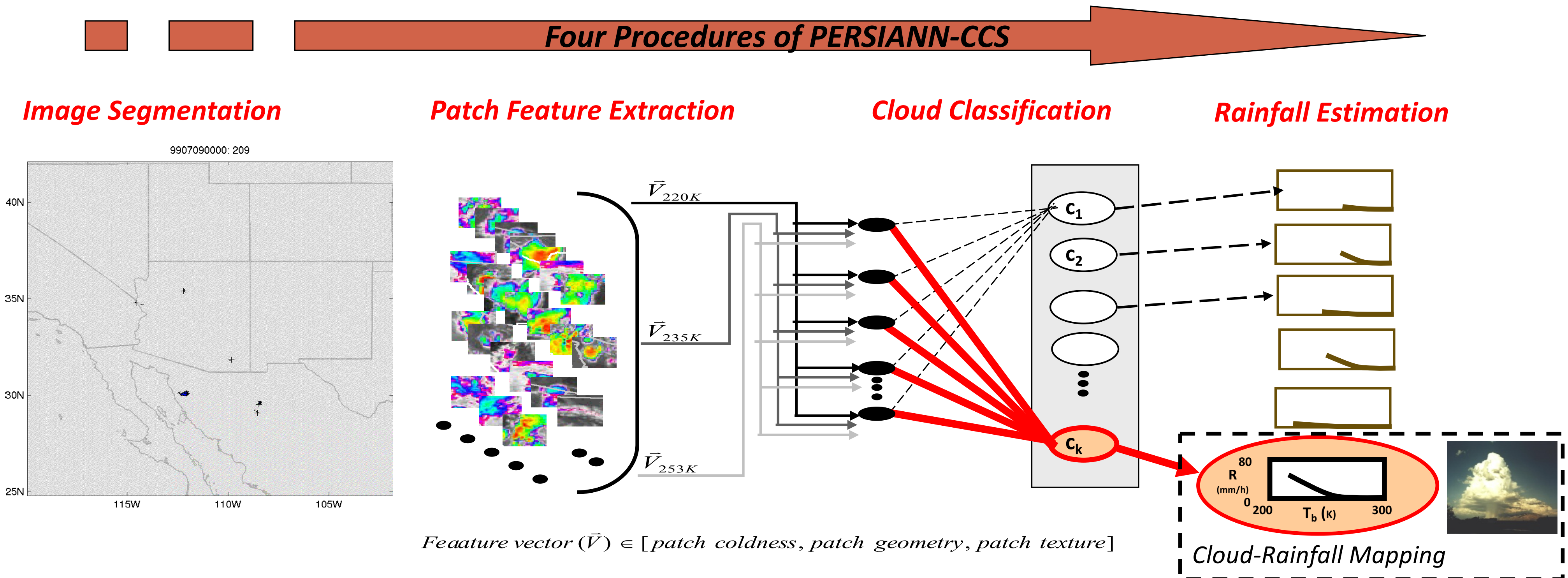
Bias and uncertainty increases when more weight given to IR

IMERG error analysis: impact of precipitation features

	IMERG estimate	IMERG estimate + Rain fraction	IMERG estimate + Convective contribution	IMERG estimate + Variability
Stratiform reference explained variance	18%	42%	-	62%
Increment		*+24%*	-	*+44%*
Convective reference explained variance	12%	23%	55%	72%
Increment		*+11%*	*+43%*	*+60%*

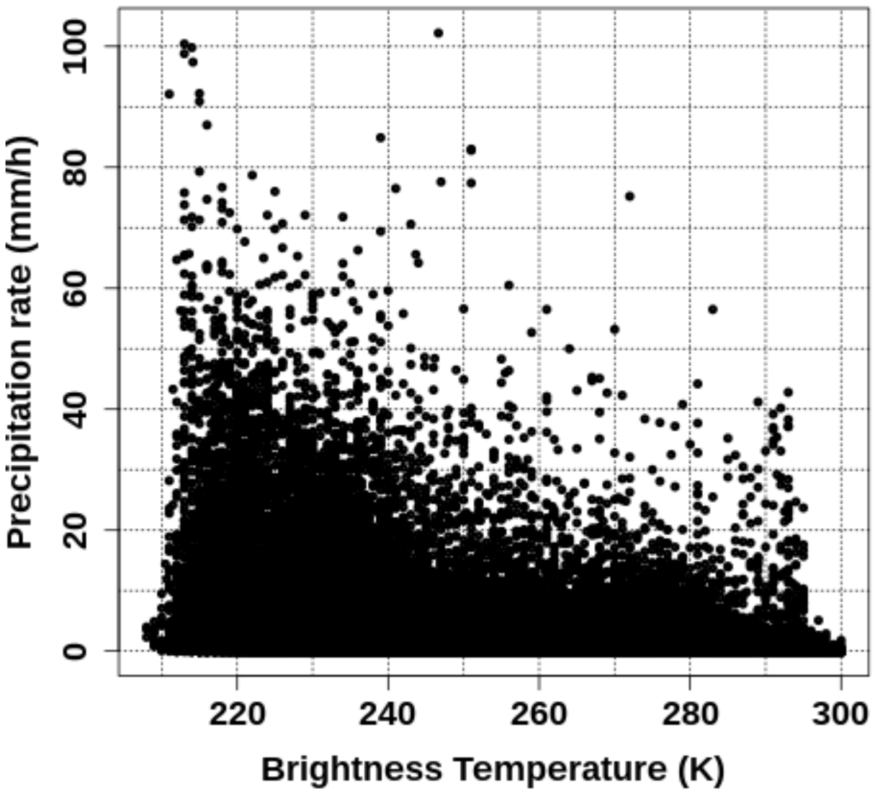
- **Significant part of the IMERG systematic error explained by precipitation features ➔ potentially interesting to include in the retrieval**
- **Basis for systematic / random error modeling and probabilistic retrievals**
- **Predict the IMERG regional and seasonal uncertainty**

IMERG Infrared part:
Precipitation Estimation from Remotely Sensed Imagery using Artificial Neural Network-Cloud Classification Systems



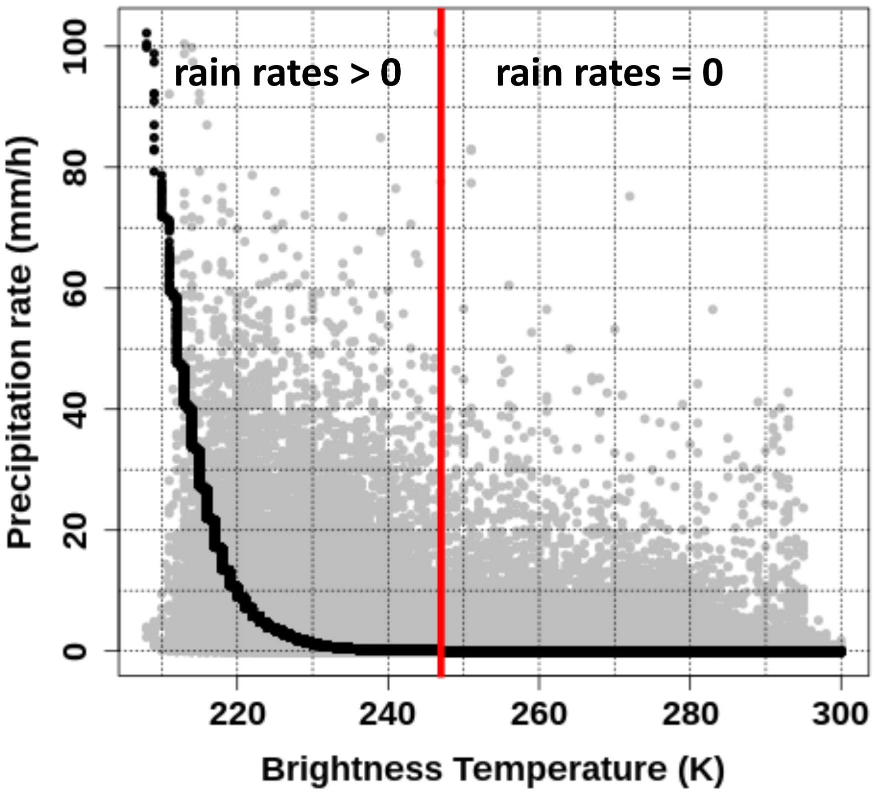
Courtesy Y. Hong

Analyzing PERSIANN-CCS cluster #306



- Dispersion in the relation Tb(IR)-RR, including rain/no-rain and positive values
- General decrease of rain rates with higher Tbs

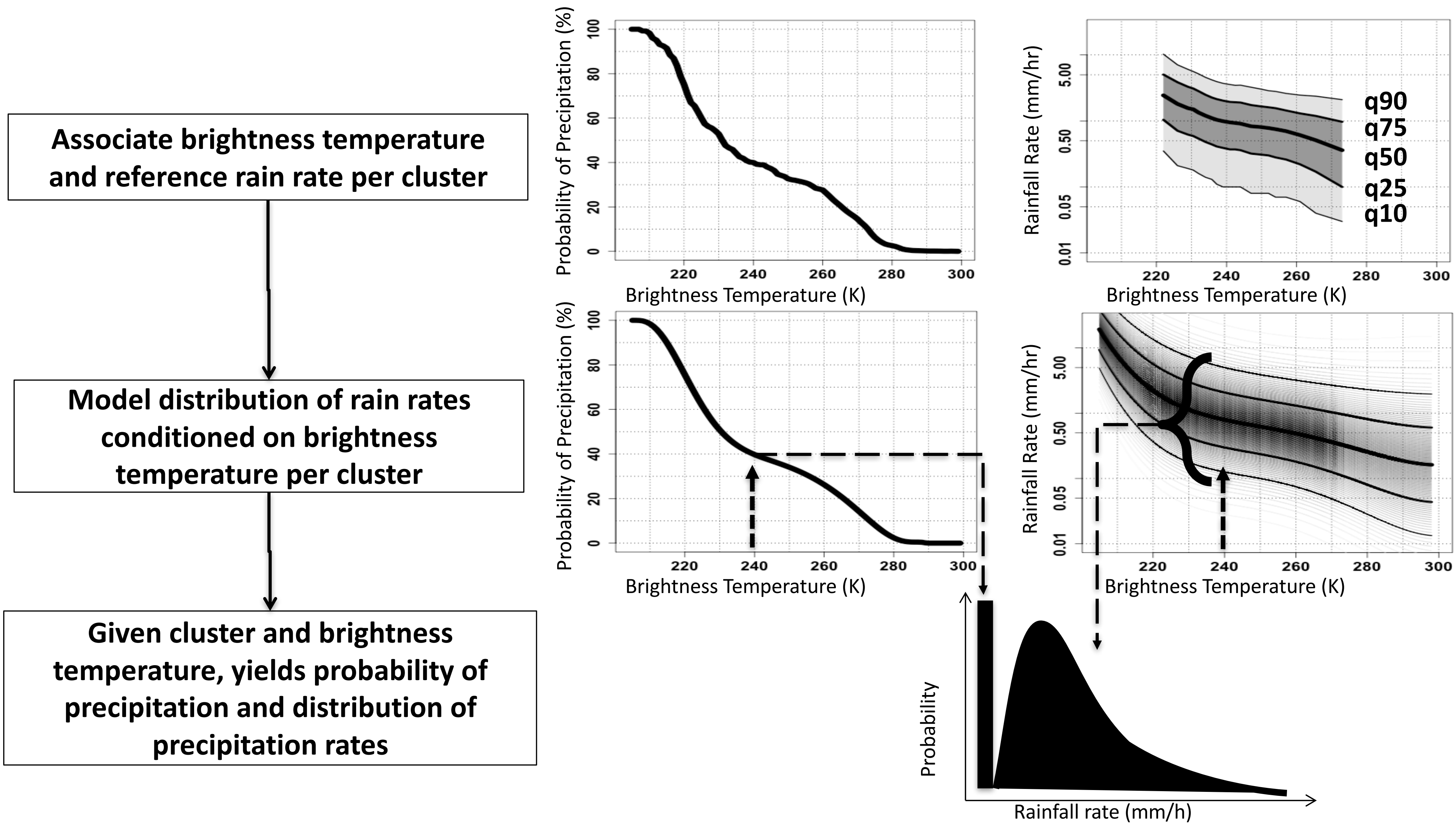
Analyzing PERSIANN-CCS cluster #306



- **Positive rain rates observed for Tb > 247K**
- **Zero rain rates observed for Tb < 247K**
- **Significant conditional bias:**

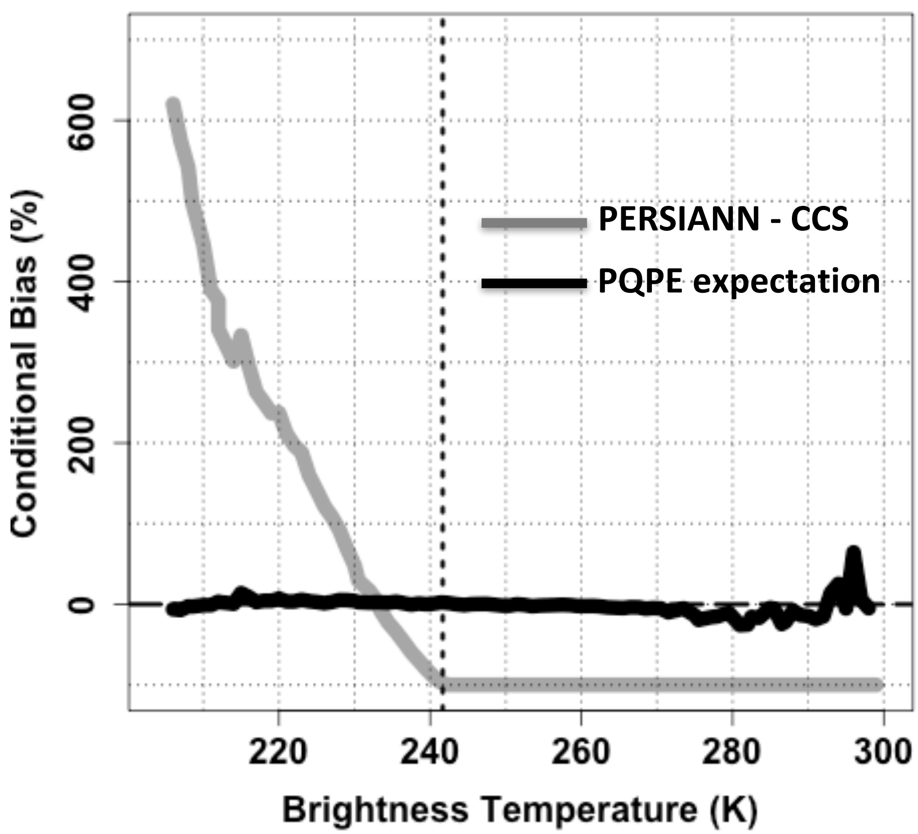
overestimation Tb < 220 K, underestimation Tb > 230 K

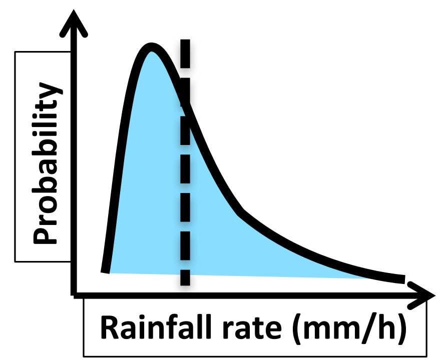
- **Extreme rain rates associated with lower Tbs than observed**


Associate brightness temperature and reference rain rate per cluster
Model distribution of rain rates conditioned on brightness temperature per cluster
Given cluster and brightness temperature, yields probability of precipitation and distribution of precipitation rates
Probability of Precipitation (%)
Brightness Temperature (K)
Rainfall Rate (mm/hr)
q90
q75
q50
q25
q10
Probability
Rainfall rate (mm/h)

Probabilistic QPE using Infrared Satellite Observations

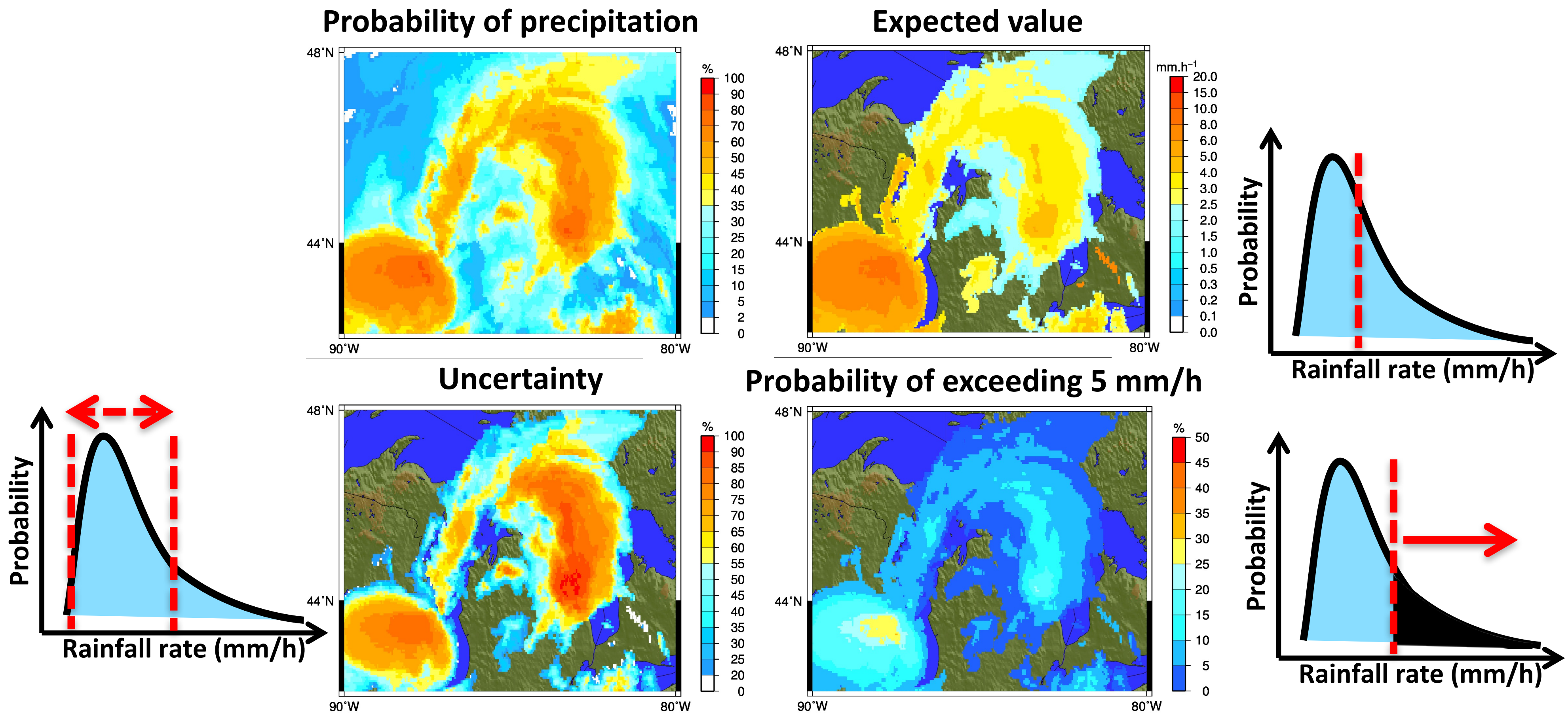
Conditional bias





Kirstetter, Karbalaee et al., cond. accepted in QJRMS

Probabilistic QPE using Infrared Satellite Observations



precipitation system at 1200 UTC on June 17, 2014

Assessing GPM with MRMS: current status and future directions

1. Context on MRMS and GPM

2. Dual-frequency Precipitation Radar

3. GPM Microwave Imager

4. IMERG

5. Conclusion & perspectives

Assessing GPM with MRMS: current status and future directions

1. Dual-frequency Precipitation Radar

- $R\text{-}D_m$ relation
- Probabilistic QPE

2. GPM Microwave Imager

- Influence of surface (Land Surface Working Group)
- Precipitation types

3. IMERG

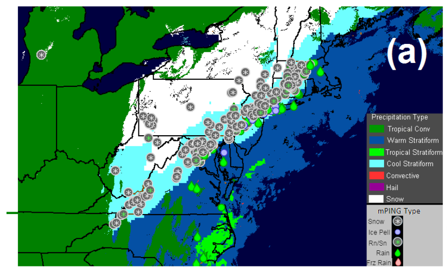
- Impact of precipitation features, weight given to IR
- Probabilistic QPE

Assessing GPM with MRMS: current status and future directions

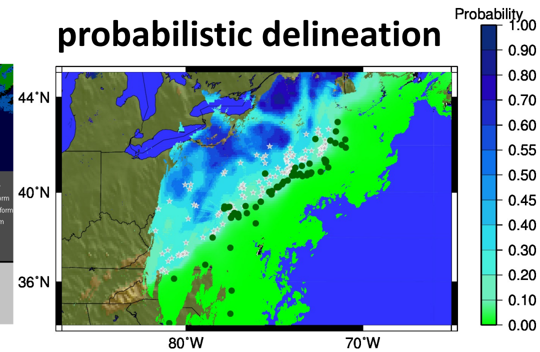
Probabilistic Quantitative Precipitation Estimates with ...

- **MRMS Rain/Snow delineation**

current



probabilistic delineation



- **MRMS snow water equivalent**

PDF(SWE) = f (Z, T, H)

	MRMS	PQPE 1D (Z)	PQPE 3D (Z, T, H)
Bias (%)	-45.5%	-0.02%	0.67%
Correlation	0.48	0.49	0.59

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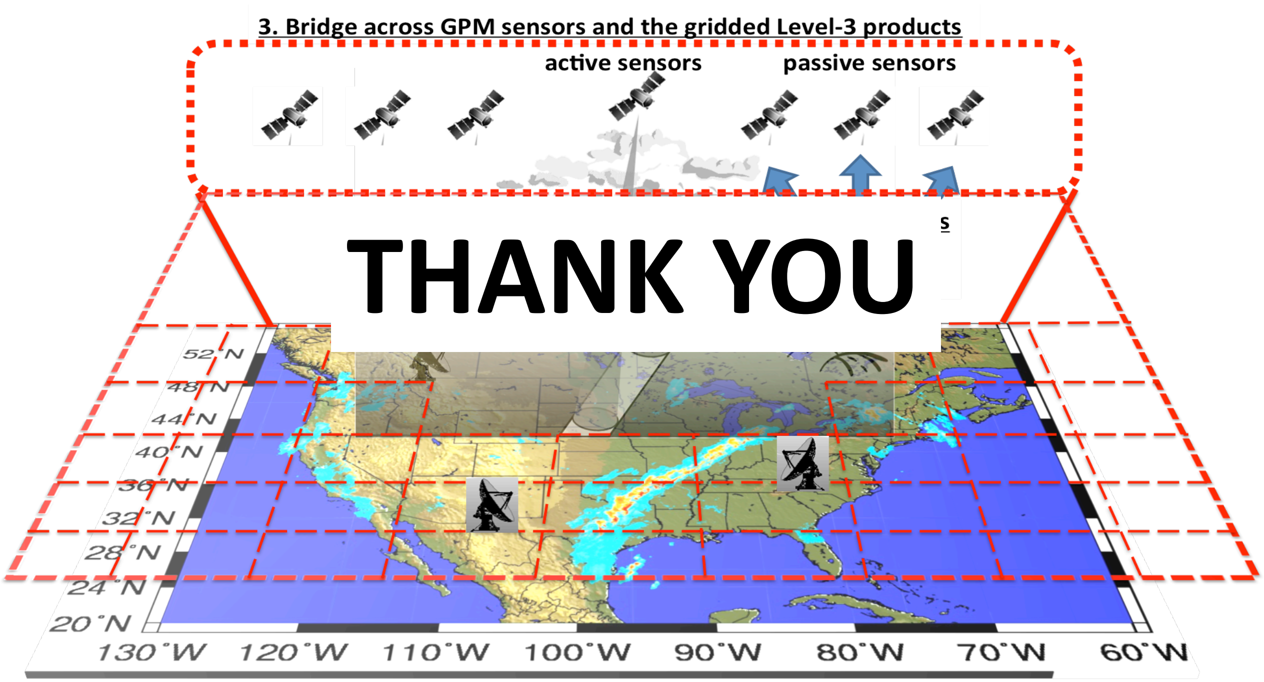

This work is made possible through support by NASA Ground Validation program and Precipitation Measurement Mission program.